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Technical Communication No. 2

Nutrition in Relation to Reproduction with Special Reference to Sterility in Farm Animals

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ADDENDUM TO TECHNICAL COMMUNICATION No. 2.

HART, E. B., HADLEY, F. B. and HUMPHREY, G. C. **The relation of nutrition to contagious cattle abortion.** *Agric. Exp. Stat., Univ. Wisconsin, Madison,* 1932. *Res. Bull.* No. 112, pp. 45.

For this experiment 44 heifer calves were procured from herds free from contagious abortion, as judged by negative agglutination reactions. They were divided into two groups, of which one was fed on a " good " ration of corn silage, good quality alfalfa hay, a grain mixture of yellow corn, oats, wheat, bran and oil meal, supplemented with iodized salt and bone meal, and the other on a " poor " ration of the same silage, timothy hay grown on acid soil, a grain mixture of yellow corn, oats and gluten meal, supplemented with common salt only. Both groups were pastured in summer, the " poor " group on timothy and June grass. The " good " ration provided more protein, fat, P, much more Ca and iodine than the poor, but records of growth, fertility and milk production (average about 1000 gallons) indicate that the poor ration met all requirements. Analyses of the bones of some of the animals slaughtered at the beginning of the 4th lactation showed no difference in Ca and P reserves. Estimations of Ca and P in blood gave 11·03 mg. Ca and 4·54 mg. P on the " good " ration and 10·75 mg. Ca and 4·97 mg. P on the " poor " ration, figures such as would be expected from the relative intakes of Ca and P, which were 158 g. Ca and 74 g. P for the former and about 28 g. of each for the latter.

All the heifers calved normally and, after they had been shown to be pregnant for the second time, they were infected with *Br. abortus* by feeding infected material or by subjection to contact infection. The infected material was derived from several aborted fœtuses and therefore contained different strains of *Br.* and other organisms. Certain differences in the behaviour of the two groups appeared. The

initial number of reactors was approximately the same, but the cows in the " good " group showed higher agglutination titres, more abortions and more persistent positive reactions, while udder involvement with infection of the milk was entirely confined to the " good " group. In the " poor " group all of the initial reactors became non-reactors within 2 years, whereas 25 per cent. of the initial reactors in the " good " group remained reactors. As a consequence breeding efficiency was considerably higher in the " poor " group. There does not therefore appear to be any advantage from the higher plane of nutrition in the " good " group.

It is of interest that in these experiments, the higher the agglutination titre, the greater was the probability of both abortion and udder infection.

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NUTRITION IN RELATION TO REPRODUCTION, WITH SPECIAL REFERENCE TO STERILITY.

The occurrence of sterility in farm animals, and more particularly in dairy herds, is so common as to render it a problem of first-class importance. An inquiry into wastage in dairy herds, made at the Hannah Dairy Research Institute (1), showed that disease disposals constitute 44·3 per cent. of the total, and that reproductive troubles, failure to breed and abortion, form the largest single class of causes, totalling 19·3 per cent. of the whole. Similar studies in Kent (2), covering a total of 82 herds during 1928-30, showed that sterility was the chief single cause of disposals, accounting for 26 per cent. of the total, and studies in Cambridge for the year 1928-29 (3) gave a similar result with 23·72 per cent. of disposals due to sterility. In the two latter studies the annual general replacement rates were between 20 and 25 per cent. The problem appears to exist wherever intensive dairy farming is practised. In many areas it is important also under extensive conditions, and, although accurate data do not appear to exist, it is evident that sterility is commonly regarded as one of the major problems of animal husbandry throughout Europe and in the Dominions (4).

The problem of sterility is possibly less acute in other classes of farm stock than in dairy herds. In pigs the incidence varies greatly and appears to be, to a large extent, dependent on management (5). But breeding difficulties exist in all classes of stock, and the sum total of losses involved must represent a very considerable total.

From the practical point of view, sterility in the female is of greater importance than in the male. The subject will, therefore, be discussed chiefly in regard to the female. The causes of sterility may conveniently be dealt with under two main heads, infective and nutritional.

Infections in Relation to Sterility.

Contagious Abortion.—The chief cause of sterility in this class and, according to some observers, the chief cause of sterility generally, is

contagious abortion. The disease is very widespread, and appears to be increasing rather than decreasing (6, 7). It is difficult, however, to make a true estimate of its importance as a cause of sterility. The initial losses of calf and milk are so great that the tendency is to early disposal. Dalrymple-Champneys (8) states that 80 per cent. of infected cows abort only once, and Smith (9) considers that recurrence of abortion and chronic disease are due, not to the abortion bacillus, but to secondary infections with other pyogenic organisms. According to Robin (10), the number of infected cows that become sterile, following abortion, is estimated by different observers at from 20 to 75 per cent. Davis and Morgan (11) found that 20 per cent. were sterile following a single abortion and a further 10 per cent. became sterile after a time. Gwatkin (12) found either difficulty in breeding or sterility in 17·7 per cent. of reactors as compared with only 3·9 per cent. in non-reactors. On the other hand, there are observers who consider contagious abortion of minor importance as a cause of sterility (13, 14), and who state that sterility is not more frequent where abortion is common than in abortion-free areas (15).

Other Infections.—Other conditions of infectious origin, regarded as causes of sterility, are endometritis and vaginitis. It is suggested that sterility may accompany vaginitis because of the existence in such conditions of "spermatoxins" and "spermalysins" (16). Endometritis has been thought to act in the same way, or to have a more direct action by preventing implantation of the ovum. Endometritis appears also to be associated in a large number of cases with functional disturbances or degenerative changes in the ovary, consisting in interruption of the normal cycle, either during maturation of the ovum with atresia and cystic degeneration of the follicle, or by failure of absorption of the corpus luteum and consequent prevention of maturation of other follicles. Some consider that these changes are caused by the uterine infection ; others consider that nutritional inadequacy may be to some extent responsible for both the infection and the ovarian changes.

Meigs (17) put forward the suggestion that dietary deficiencies, in particular deficiency of calcium, might be partly responsible for susceptibility to contagious abortion. No evidence appears to have been forthcoming in support of this idea. Smythe (18) states that contagious abortion in Cornwall is more common on granite soil than on any other type, and attributes the difference to dietary deficiency. On the other hand, White, Rettger and Chapman (19) did not find that

prolonged feeding of calcium and phosphorus cured or prevented the infection. Folmer Nielsen (20) points out that the importance of contagious abortion depends, chiefly, on its chronicity. If this, as Smith suggests, is due, not to *Br. abortus*, but to other organisms, it might be thought that, following the first abortion, the condition should be regarded in the same way as other infections.

There appears to be good ground for the view that diet affects susceptibility to infection. Williams (21) (87) points out that bacteriological studies show that the organs of the non-pregnant cow contain many bacteria which are usually harmless, but assume a pathogenic rôle under unfavourable influences. Such unfavourable influences, he suggests, are to be found in improper feeding. Nielsen (20) shows that the incidence of uterine infections and of the associated ovarian changes increases with number of gestations and lactations, and he considers that this implies a lowering of resistance which might be avoided by attention to diet. These suggestions are in complete agreement with what is known of susceptibility to infections of other areas (22). Deficiency of vitamin A alters the condition of the mucous membranes of the respiratory passages, and the defence mechanisms of the body, so that organisms which normally exist in the body without causing signs of disease become pathogenic. A rickets-producing diet, fed to rats which are normally immune to tuberculosis, causes them to become highly susceptible. Hence there is an increasing tendency to believe that these infections of the genital tract may be, to some extent at least, the result of poor condition and improper feeding. Stalfors (23) considers that catarrhal conditions of the uterus may depend on lack of tone in the uterine muscle, and that the effect of iodine irrigation, as frequently practised, may be due to the stimulant action rather than to any antiseptic property of the solution used. An excellent review of this question is given by Quinlan (24), who is also of opinion that the adequacy of diet has not received sufficient attention.

Ovarian Changes.—Again, although it cannot be denied that ovarian changes may arise in consequence of infection of other parts of the genital system, there is abundant evidence that such changes may be the direct result of faulty nutrition. Presumptive evidence is afforded by the conditions under which ovarian disease usually occurs. According to Hess (13), cystic degeneration of the ovaries occurs most frequently in early maturing, high-milking breeds, and it occurs at an earlier age where breeding and milk production are intensive. Although actual statistical data do not appear to exist, this seems to be the

consensus of opinion. It implies that the nutritional demands for early maturity, frequent breeding and sustained high-milk production are not fully met. Conklin (25) definitely attributes to this cause the sterility following record-breaking performances in milk production. He points out that the animals are usually stall-fed for long periods on diets exceedingly rich in concentrates, and that actual symptoms of deficiency (bone disease) occur. The output of mineral matter in high milk production is enormous, and, unless special provision is made to meet the requirements, depletion of the skeleton is bound to occur. Stockklausner (15) and Frei (26) both regard this as one of the causes contributing to produce sterility.

Malnutrition in Relation to Sterility.

Under-nutrition.—Fertility depends, in the first place, on the simple quantitative adequacy of the diet. Famine and war sterility, or diminished fertility, is known in all classes of farm animals and in human beings. Following the Great War, sterility was common in cattle, goats and sheep in Germany and Hungary (14). In goats sterility increased from the normal, about 5 per cent. to 20 or 25 per cent., and in sheep from 10 to 40 per cent. Under-feeding is well known as a cause of sterility in range herds and in sheep on poor pastures. Indeed, it has been suggested that the natural habitats of sheep have been determined by the limits within which climatic conditions allow a sufficiency of natural pasture (27). On poor grazings the lamb crop may be as low as 25 to 50 per cent. (28).

Experiments by Loeb (29) indicate how this sterility may be produced. In guinea-pigs, underfed on a normal ration, degeneration and atresia of the maturing ovarian follicles occurred, with failure of ovulation and complete sterility.

Over-feeding.—On the other hand, over-feeding is also known to be detrimental to optimal breeding performance. In cattle "show condition" and in sheep "high condition," as produced for flock competitions, are associated with low fertility or failure to breed (30, 27). In brood sows, over-fatness appears to be a common cause of sterility. According to some veterinarians, cystic changes in the ovary occur most frequently in fat animals.

Flushing.—In contrast to the effect of continued high condition, a stimulating effect on ovulation is produced by flushing (31). It appears that the nature of the feed used to produce the flush is relatively un-

important. In animals that are fit, but not over-fed, any sudden increase in feed will stimulate ovarian activity, promote the occurrence of oestrus and increase the number of ova shed. In a series of observations (32) on a total of 1033 flushed ewes, the number of lambs per 100 ewes was 154, as compared with 140 in 4054 ewes not flushed. In another series (33), flushed on extra good pasture, the lambs per 100 ewes were 164, as compared with 143 from control ewes.

Phosphorus Deficiency.—Naturally occurring deficiencies of mineral elements have been shown to affect fertility. Of these, possibly the most important is deficiency of phosphorus, since it is of widespread occurrence in natural pastures throughout the world. It has been shown by Theiler and his associates in South Africa, by Henry in Australia, and by Eckles, Becker and Palmer and Hart in the United States, that deficiency of phosphorus results in abortions and sterility. In observations on 200 native scrub cows, half of which received a supplement of bone meal, Theiler, Green and Du Toit (34) found that 80 per cent. of the bone-meal lot calved normally, while only 51 per cent. of the controls calved. Du Toit and Bisschop (35) report an experiment continued for three years with 109 bone-meal-fed cows and 20 controls in which the bone-meal-fed group produced 87·3 per cent. of the possible number of calves, while the control group produced only 56·5 per cent. of the possible number. Eckles, Becker and Palmer (36) also found that feeding a phosphate supplement improved fertility. They attributed the low fertility associated with phosphorus deficiency to infrequency of ovulation. Hart (37) finds that, in certain range areas in the States, where the calf crop is low, the pasture, although quantitatively sufficient, is deficient in phosphorus and protein and the calcium/phosphorus ratio is high. On such pastures cows become emaciated and oestrus does not occur. Laboratory experiments on rats, designed by Hart to throw light on the causation of this sterility, have shown that under-nutrition stops the normal cycle of ovarian changes, and that a diet low in protein and phosphorus, or with a high calcium/phosphorus ratio, interrupts the cycle or greatly lengthens the interval between ovulations. Hart describes trials in supplementary feeding in which a supplement of cotton-seed cake, rich in protein and minerals, gave excellent results, 50 per cent. of the cows being re-bred within a month after calving.

Calcium Deficiency.—It is not generally considered that deficiency of calcium occurs to any great extent under natural conditions. It is, however, known to occur in some areas, for example the Falkland

Islands and hill pastures in Scotland (38). In most cases observations on such areas are complicated by the co-existence of general under-nutrition. We have, therefore, no data regarding the effect of calcium deficiency on fertility under natural conditions.

In experiments in which dairy cows were fed greatly restricted rations, confined practically to a single fodder-plant, oat, wheat or maize, Hart (39, 40, 41, 42) and his co-workers showed that addition of calcium was essential to secure reproduction. The results were further improved by addition of butter or cod-liver oil and salt. Hart also records that cows fed on hay and straw grown on acid soils and containing less than the normal percentage of calcium were unable to produce normal healthy calves. In an experiment using a ration of low calcium content Meigs (43) found that cows were very difficult to get in calf, while controls with a supplement of calcium carbonate gave much better results. Kennedy found that animals on a diet deficient in calcium were sterile, although ovulation occurred. The uterus was pale, flaccid and in a state of inactivity. Simmonds (44) found, in extensive experiments on rats, that a minimum percentage of calcium in the ration was necessary for successful reproduction, and that increase above the minimum gave improved reproduction with better condition of the parents. An interesting observation by Küst is quoted by Frei (45), namely that rickets and nymphomania occur together in the same herds. Davidson (46) has shown that protracted deficiency of calcium in the ration of breeding sows leads to a very considerable increase in the number of pigs born dead. The effect is cumulative, becoming more pronounced in the second and third generations. A salt mixture, representing the mineral elements of blood meal, had a marked effect on the occurrence of oestrus after weaning. Withholding this mixture delayed the appearance of oestrus. From the composition of the ration, it is inferred that the effect was due either to potassium or to iron.

Other observations in which the chief deficiencies concerned were probably of calcium or phosphorus or both, are the following. Rettger, White and Chapman (47), in an experiment designed to produce contagious abortion in young heifers by feeding suspensions of cultures of *Br. abortus*, fed their experimental animals first on pasteurised milk and later on a ration of corn meal, ground nuts, linseed oil meal, bran and sodium chloride, with green food only occasionally. No contagious abortion developed, but great difficulty was experienced in breeding, the control group being even more affected than those fed the cultures.

After three months on a " well-balanced ration " they came in heat, and were successfully bred. Kossmag (48) observed that the occurrence of abortions was prevented when a silica-rich, base-poor diet was replaced by one poor in silica and including sodium chloride and calcium chloride.

Cotton and Buck (15) state that the abortion rate in a herd numbering over 200, and negative to contagious abortion, was from 5 to 13 per cent. They believe that some dietetic deficiency must be the cause, although the ration fed was, in their opinion, adequate. McGilvray (49) also holds the view that mineral deficiency lowers resistance to abortion disease and increases sterility. This would be particularly liable to occur in herds stall-fed on restricted rations. Graves (50) found that foxes reared in captivity failed to breed until the meat in their ration was reduced and green vegetables were supplied.

Iodine Deficiency.—In areas of endemic goitre throughout the world, breeding difficulties in domestic animals tend to occur (51). It was first shown by Ennis Smith (88) that premature birth and imperfect development of the young in pigs could be prevented by administration of iodine to the sows. Stiner (89) and Schropp (90) have both found that administration of iodine, either as an inorganic salt or in pasture manured with iodine, had a beneficial effect on fertility, the number of services required being reduced. Müller-Lenhartz and v. Wendt (91) found similar results to follow the feeding of a mineral mixture containing calcium, phosphorus, iron and iodine.

It has also been suggested that conditions of relative iodine deficiency might arise in areas where deficiency of iodine is not thought to occur, under conditions of intensive feeding. The results of a four years' experiment at the Rowett Institute suggest that in stall-fed cows there may be a relative deficiency of iodine adversely affecting reproduction (communicated).

Fluorine Excess.—Experiments are accumulating to show that an excess of fluorine in the diet may have a detrimental effect on fertility. Since excess of fluorine occurs under natural conditions in at least two known areas (Morocco and some districts in U.S.A.), the experimental findings may be of some practical significance. In Morocco, excess of fluorine in the drinking water gives rise to pathological conditions in sheep (52, 53, 54), and in the U.S.A. a similar excess is held responsible for abnormal dental enamel in man (55).

McCollum and his co-workers (56) found that feeding fluorine as sodium fluoride at a level of 0·05 per cent. of the ration had no effect

on fertility. Similarly, Schulz and Lamb (57) found no impairment of reproduction from feeding 0·05 to 0·1 per cent. of the ration as sodium fluoride, but Bergara (58), feeding 5 mg. sodium fluoride per rat per day, failed to get reproduction. Del Castillo (59) and Chaneles (60) also found injurious effects. Velu (61), on the basis of experiments in which he has shown that continued administration of fluorine to rats causes suppression of the oestrous cycle, suggests that similar effects may be produced in domestic animals from long-continued consumption of fluorine-containing water.

Protein Deficiency and Excess.—In natural grazings a deficiency of phosphorus is usually correlated with a low nitrogen content of the pasture, especially in the mature herbage and under drought conditions. Hart (37), from his observations on range pastures, lays stress on the dual deficiency. In many cases it would be impossible at present to judge what part of the effect of such grazings in reducing fertility is due to under-nutrition and what part to deficiency of phosphorus or protein.

Numerous experiments on small animals have been made which show the great importance of both the amount and the quality of the protein supplied for breeding efficiency. In a series of experiments on rats, Slonaker and Card (62, 63, 64) showed that the age at puberty, the length of the reproductive span and the size of litters were all affected by the quality of the protein fed. Rats receiving animal protein matured earlier than those receiving only vegetable protein; the intervals between litters were about two months in the former and varied up to four months in the latter. The period of reproductive activity on animal protein was seventeen months; on vegetable protein only two to seven months. Sterility was high on vegetarian diet; the number of young in litters was greatly reduced and the effect was cumulative, the vegetarian rats being completely sterile in the third generation. Simmonds (44) showed that a diet in which only vegetable protein was supplied greatly reduced fertility, while a high proportion of animal protein increased it. Wan and Wu (65) also found a significant difference in litter size in favour of omnivorous, as compared with vegetarian, rats. Later, Slonaker (66) showed that there is an optimum protein level for reproduction at 14 per cent. of the ration (animal protein), higher or lower levels giving diminished litter size and increased sterility. This level was also best for length of reproductive span. A large excess of animal protein over the optimum level causes pathological changes in the ovary and promotes sterility (67).

The difference in value between animal and vegetable protein for

reproduction may possibly be due to deficiency of essential amino-acids in the latter. Courrier and Raynaud (68) have shown that rats fed on a diet deficient in lysine showed no sexual cycle. Males on the same diet had relatively poorly developed testicles.

In poultry feeding it is well recognised that sufficiency of calcium and phosphorus and an adequate supply of good quality protein are essential for egg production. Optimum quantities and ratios are being determined by experiments at all the main centres of research (69, 70, 71). According to the most recent results, plant protein, adequately supplemented with calcium and sodium chloride, may give as good results as animal protein. There are, however, no data to show whether this is true for mammals.

Vitamin Deficiency.—The vitamin most clearly connected with reproduction is vitamin E (72). This vitamin is fat soluble, and occurs in nature chiefly in green vegetables, notably lettuce, and in the embryos of certain cereals, especially wheat. It is found in milk and egg-yolk, and is present in muscle, fat, pituitary, placenta, and to a less extent in intestine and liver. It does not occur in plant oils, and is apparently absent from cod-liver oil, kidney, brain and testis. A diet free from vitamin E does not prevent maturation or shedding of ova in rats, and implantation is normal. A first litter may even be born, but as depletion of reserves proceeds, a characteristic condition with death and absorption of the fœtus results. In males, spermatozoa become non-motile, then disappear, while germinal epithelium degenerates and testis weight is reduced.

More recently, it has been shown that a deficiency of vitamin A also causes degeneration of the germinal epithelium, and complete sterility (73, 74, 75). This effect is more rapidly produced than that of vitamin E deficiency.

From time to time it has been suggested that other vitamins were necessary for reproduction. It is doubtful, however, whether deficiency of vitamin B has any specific effect on fertility. The present position (76) appears to be that the effect on fertility of deficiency of vitamin B is due, not to lack of the vitamin itself, but to the inanition characteristic of the condition. Vitamin D appears, at least under certain conditions, to be necessary for normal reproduction in birds, but this is again probably only a secondary effect associated with the effect of vitamin D on mineral metabolism and the high mineral requirements for growth of the egg.

It is uncertain whether deficiency of vitamins affecting fertility

occur under natural conditions. It has been suggested by Velu (77) that deficiency of vitamin E may be the cause of a condition in sheep in Morocco in which pregnancy occurs, followed by death and absorption of the fœtus. The point does not appear to have been experimentally investigated. It has also been thought that vitamin E might be deficient in the rations of farm animals, particularly those stall-fed on poor rations. Experiments have therefore been made by Graves and Miller (78), and by Rogers (79) in the United States, and at the Department of Animal Genetics in Edinburgh (communicated) to test whether the feeding of sprouted oats would influence sterility in cases not attributable to any definite pathological condition. The results, although suggestive, are inconclusive. (There appears to be some doubt as to whether sprouted oats contain any considerable amount of vitamin E.) On the other hand, Vogt-Møller and Bay (80) claim that a single intramuscular injection of an ether extract of wheat germ cured sterility in cows kept under poor conditions on a restricted feed.

Glands of Internal Secretion.—At least two glands of internal secretion have definite correlations with, and effects on, the ovary (81, 82). These are the thyroid and the anterior lobe of the pituitary. Either a deficiency or an excess of thyroid secretion will interfere with ovarian function, causing cessation of ovulation and sterility. The anterior lobe of the pituitary produces two hormones; one appears to be necessary for maturation changes in the ovary, the puberty hormone, and the other promotes luteinising changes. Injection of the former into immature animals causes early puberty; of the latter, excessive production of lutein with inhibition of follicular development and sterility. It has been found that extracts of anterior pituitary may replace vitamin E in a deficient diet, and that the anterior pituitary ceases to be active in animals fed on a vitamin E deficient diet. Some correlation, therefore, appears to exist between vitamin E and the hormones of the anterior pituitary. It is also known that underactivity of the thyroid (simple goitre, cretinism) is, in some way, correlated with iodine metabolism, and that over-activity may, to some extent at least, be controlled and modified by diet (83). Sterility due to disturbance of the functions of these glands may, therefore, ultimately be due to lack of dietary balance of a kind not yet fully understood.

Interesting observations have been made on the effect of diet on the production of spermatozoa. Polowzow and Naguzew (84) have shown that production in the stallion is definitely related to quality of

food, and that eggs and bran have a stimulating effect. Parchutin (85) records exactly similar observations.

Nordby and Bollen (86) describe a case of temporary sterility in a boar fed on Canadian field pea screenings. A change of diet to barley, oats, tankage, oil meal, alfalfa and sodium chloride resulted in complete restoration of fertility in six weeks. At the time of the change in diet the p_H of the semen was 7·61, and motility of the spermatozoa was "very unsatisfactory." On the altered diet the p_H fell to 7·35 and motility improved along with the reduction of p_H.

This last observation suggests a possibility that the supposed effect of infections of the female genital tract as due to "spermatoxins" and "spermalysins" might, in reality, be the effect of a change in p_H. It has been shown that such an alteration, for instance in regard to wound infections, may completely change the nature or pathogenicity of the organisms present, and changes in the p_H of body fluids and secretions may easily be effected by diet. Hence the infections themselves and the supposed toxic effect on spermatozoa might both be due to an abnormal p_H.

Conclusion.—This brief review of the literature shows that undernutrition or malnutrition due to imbalance of the constituents of a diet, vitamins, proteins or minerals, may seriously interfere with normal reproduction. The influence of such faulty diets has been clearly demonstrated in experimental work with laboratory animals. It is known that similar defective diets occur, with similar results, under extensive conditions of animal husbandry, and they may be reproduced under intensive conditions on artificial rations. No data exist to indicate to what extent such factors do actually affect fertility in practical, intensive or semi-intensive, farming, but they may be of considerable economic importance.

In addition to this direct influence of diet on fertility, there is the other, possibly even more interesting and important, indirect effect through its modifying action on susceptibility to infections. It is known that malnutrition practically determines susceptibility to certain infections, and there is evidence that it may be an important predisposing factor to infection with *Br. abortus* and other organisms which interfere with reproduction. It is perhaps unlikely that an organism of the apparently high virulence of *Br. abortus* should become innocuous under the most perfect dietary conditions, but the relative importance, as regards subsequent sterility, of malnutrition of the host and virulence of this or other infecting organism, has not yet been

established. There is obviously urgent need for further extensive investigations on the whole subject of nutrition in relation to reproduction and the various infections which interfere with conception and the normal development of the fœtus.

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